HENRIK HARDER HOVGESEN, PETER BRO, NERIUS TRADISAUSKAS,
AALBORG UNIVERSITY
THOMAS SICK NIELSEN, UNIVERSITY OF COPENHAGEN

TRACKING VISITORS IN PUBLIC PARKS *EXPERIENCES WITH GPS IN DENMARK*

INTRODUCTION

Very little scientific research based upon GPS tracking in a Danish context has been conducted and up until the present, no research at all has included comprehensive GPS tracking of human activity (cf. Jensen & Guldager, 2005; Jensen, 2003). There is therefore a need for explorative studies evaluating different tracking hardware and methodological set-ups and identifying various difficulties that may arise during data collection (Hovgesen etal, 2005). From 2003 up to the present, the Diverse Urban Space (DUS) research project has conducted various experiments with the use of GPS tracking as a survey instrument relevant to urban planning. This work has involved cases including the simple testing of equipment and both small and large scale surveys.

This chapter will first provide a concise overview of the different surveys and tests conducted within the DUS and briefly explain the main methodological experiences. Hereafter, a specific case in which GPS technology is applied to track the movements of park visitors will be dealt with in more detail with regards to the methodological set-up, results and applied hardware. In addition to the explanation of the general surveying technique and the results, one park in particular is used to illustrate a simple analysis of how Google Earth may be used in connection with real time visualisation undertaken on the basis of GPS tracking. Lastly, conclusions drawn from the park surveys and a number of more general conclusions on the basis of various other surveys are provided.

THE CASE STUDIES CONDUCTED WITHIN DUS

The following cases were conducted within DUS:

Case 1	Adults in Copenhagen; employees at Danish Centre for Forestry, Landscape and Planning, Denmark, 2005 (N = 10)
Case 2	School Children from a state schooln Glostrup, Denmark, 2005 (N = 14)
Case 3	School Children from state school in Hjerk-Harre, Denmark, 2006 (N =18)
Case 4	High school students from Aalborg, Denmark, 2006 (N = 49)
Case 5	School Children from a state school in Aalborg, Denmark, 2006-2007 (N = 30)
Case 6	The Aalborg GPS park survey of four public parks, Denmark, 2007 (N = 4.462)
Case 7	The DUS GPS surveys in Aalborg and Copenhagen, Denmark, 2007 - 2011, (N = 500+)

The 'school children' studies (case 2 and 3) were carried out in co-operation with 'The Research Unit for General Practice in Copenhagen' at the University of Copenhagen (Denmark) whereas the Aalborg studies (case 4 and 5) were carried out in co-operation with students from Aalborg University (see Kjærsgaard et al, 2006). The Aalborg GPS park survey was conducted in co-operation with the Municipality of Aalborg. The main aim of this research was to prepare the set-up for a new type of GPS-based survey of activity patterns in time and space that will give a new perspective on spatial interdependencies and spatial effects for the benefit of urban and traffic/mobility planning. The potentialities of using GPS-based surveys are illustrated by taking point of departure in data from the Aalborg GPS park survey of four public parks, Denmark 2007, namely 'Skanseparken', case 6.

The general approach in DUS has been incremental and seeking to continuously eliminate the most problematic parts of the survey set-up and replacing them with other solutions. Hence has the number of respondents grown steadily and so has the complexity of the conducted surveys. Furthermore, the cases involved a wide range of different respondent groups and types of hardware, giving a broad insight into the different technologies. The stepwise approach meant that the DUS took a non-interventional position in its contact with respondents. Respondents were consequently not required to answer questions when they were at certain places or at certain times as in case 2, in which the respondents were sent text messages, as the latter led to extremely low response percentages and poor data quality. The DUS therefore aimed at allowing respondents to schedule when to undertake the mandatory activities required from participating in the survey.

The work carried out with different technologies showed that the main challenge was to obtain an adequate battery lifetime. The problem led to the elimination of the most advanced tracking hardware, which often had additional capabilities such as the mobile phones used in case

2. Furthermore using relative 'low-tech' hardware minimizes the possibility of respondents mishandling the equipment. Lastly, it has appeared that not all population groups are equally easy to contact with a view to acquiring respondents. Young people and children are relatively easy to contact through institutions such as schools and nurseries, whereas the fact that there are fewer obvious organized forms for adults makes it more difficult to recruit them as respondents unless the basis of the respondent selection is related to the home location.

CASE 6 - THE AALBORG GPS PARK SURVEY

The GPS Park survey was the most recent and comprehensive of the completed surveys conducted by DUS and entailed contact with many respondents of different ages and social backgrounds. This led to the compilation of a great deal of information on the practical challenges of collecting data. The purpose of the survey was primarily to gain experiences with and develop a framework for large scale data collection using GPS technology and specific hardware. However, even though the aim was not to make advanced and elaborate analyses of the collected data, the results from the survey offered an opportunity to examine some of the possibilities for real time visualisation using Google Earth. The GPS Park case study thus worked through a wide range of challenges that many different GPS-based tracking research projects must address. The case study is therefore very well suited for others to learn from as well as serving as a source of inspiration for other researchers. The GPS Park survey was developed in cooperation with the Municipality of Aalborg which needed more information on the use of local public parks. The municipality aimed at using the information in the future redesign of specific areas in parks within its boundaries.

The survey was carried out in four parks in Aalborg in August 2007 and involved 4,462 park visitors. Each park survey consisted of two separate survey parts: a GPS tracking of respondents in the park and a questionnaire survey of respondents visiting the park. The GPS Park survey was carried out in Mølleparken on Wednesday 8 August and Saturday 11 August 2007 – both days from 06.00 and 22.00. In Søheltens Have the survey was carried out on Thursday 16 August and Saturday 18 August 2007 - both days from 07.00 to 19.00. In Skanseparken the survey was conducted on Wednesday 22 August and Saturday 25 August 2007 – both days from 07.00 to 19.00 and in Kildeparken on Wednesday 29 August 2007 from 07.00 to 19.00. All above mentioned dates and time intervals were prearranged with the Municipality of Aalborg.

In conformity with the prearrangements made with the municipality of Aalborg certain survey representatives were placed at a number of specific park entrances in each park. According to the agreed survey set-up the survey representatives at the chosen entrances approached all visitors entering the specific park inviting them to participate in a survey carried out by Aalborg

University in co-operation with the Municipality of Aalborg. If visitors declined to participate in the survey, the survey representative attempted to carry out a refusal survey consisting of only a limited number of questions.

If the visitor agreed to take part in the survey, he or she was given a GPS unit making them an official respondent. Respondents were asked to carry the GPS unit throughout their park visit up to the time that they were about to leave the park. At the exit of the park the respondents were furthermore asked to fill in a questionnaire. If survey representatives ran out of GPS units or encountered respondents who did not want to carry a GPS unit but were nevertheless willing to participate in the survey, this latter group was only subjected to the questionnaires carried out by the survey representatives at the park exit, and the GPS tracking was not carried out.

The questionnaire part of the survey therefore included all respondents who were open to being contacted at one of the chosen entrances/exits and who agreed to participate in the survey. The GPS tracking on the other hand only consisted of respondents who agreed to carry a GPS unit and to whom it was possible to hand one out. The refusal survey consisted of the visitors who did not wish to take part in the park survey but agreed to participate in the refusal survey. In addition, there were also visitors who declined to participate in any of the surveys or refused all contact. These visitors were counted separately by the survey representatives. Due to the limited numbers of available hardware units (in total 50 units), the units were distributed among the entrances of the park in question in proportion to the estimated number of respondents expected to enter the park. Periodic problems in connection with handing out hardware units to all respondents only occurred in a small number of parks.

It should be noted that owing to the explorative survey set-up, the survey concerned was not representative with regard to the everyday use of the parks over a year. A further factor that should be considered is that the actual survey set-up was not efficient in obtaining data from all respondents. The actual results presented in this article consequently fail to show representative activity patterns for each park or for each week, but only on the day on which the survey was carried out.

RESULTS FROM THE GPS PARK SURVEYS

As was noted earlier, the GPS Park surveys succeeded in making 4,462 visitors participate in the survey although there were substantial differences in response in the various parks. The differences were partly due to the sizes of the parks with Søheltens Have being the smallest, Skanseparken and Kildeparken of roughly the same size and Mølleparken the largest. However the high number of visitors in Kildeparken is due to its extremely central location in the city which connects the city centre and central business district with residential areas as well as being in close proximity to the central train station and several schools. Different from the other parks Kildeparken is not only a recreational park but also a thorough fare implying that many people did not have time to participate in the survey and not everyone could be approached due to a limited number of survey representatives.

Illustration 6.1 - The number of respondents within each survey category. Note that respondents who carried a GPS also answered a questionnaire.

	GPS tracking	Questionnaire	Refusal survey	Non participants	Total number of people
Mølleparken	301	406	119	299	824
214,000 m2	37%	49%	14%	36%	100%
Søheltens Have	99	130	61	102	293
23,000 m2	34%	44%	21%	35%	100%
Skanseparken	132	153	41	104	298
67,000 m2	44%	51%	14%	35%	100%
Kildeparken	474	480	571	1996	3047
71,000 m2	16%	16%	19%	66%	100%
Total	1006	1169	792	2501	4462
	23%	26%	18%	56%	100%

The general impression from all four parks was that most respondents spent most of their time in the parks on the paths. This particularly applies to Kildeparken. However, some respondents spent a lot of time at certain locations outside the pathways. The majority of respondents who remained outside the 'traffic areas' are mainly found in some sort of 'activity area' such as a children's playground, a tennis court or a fountain surrounded by benches while only a small number of respondents spent a prolonged period of time on the lawn (cf. Ostermann & Timpf, 2007).

The Aalborg GPS park survey and the hardware units used

In the light of a number of deliberations a GPRS-based hardware unit (Flextrack Lommy©, see **illustration 6.2**) with a built-in GPS was chosen to play a role in completing the Aalborg GPS park survey. Firstly, the design of the unit is simple, the unit is light and small (only weighing 99 gram and 74x61x23 mm), and it has a single small red on/off button. Secondly, the choice of this hardware unit gave the opportunity to follow the hardware unit online and in real time so that respondents leaving the park without having passed survey representatives at the chosen entrances could be tracked and caught up with.

Illustration 6.2
Flextrack Lommy©.

Although a number of hardware units were lost and some were accidentally left in the park, thanks to the above-mentioned tracking system it was possible to locate and collect them. A few other units were collected at the respondents' home address (in total five units from all four surveys), and a total of three hardware units were completely lost during all four surveys. One unit was destroyed by a young man participating in one of the surveys, and the parts were found in the park. Contact with another hardware unit was lost in the same park during the survey and the unit not found. The last hardware unit was tracked to an address, but the potential respondent refused to return it.

The accuracy of the GPS part of the hardware unit is based on a 16 Channel parallel Very High Sensitivity receiver with a sensitivity Tracking: -158 dBm / -188 dBW and a high efficiency Helix antenna.

The Aalborg GPS park survey and the results from Skanseparken

Skanseparken had the highest percentage of respondents that agreed to participate in the GPS tracking, and it is therefore reasonable to assume that the data quality is best for this park making Skanseparken most suited for further studies.

The results from the questionnaire survey conducted in Skanseparken were based on a total of 153 respondents while results from the GPS tracking were based on 132 respondents. Refusal surveys were carried out with 41 visitors while a further 101 visitors also declined to take part in the refusal survey. None of the persons in the last-mentioned groups therefore appear in the further analyses. The total number of visitors on the two days was 298 persons distributed over 106 visitors on Wednesday 22 August and 192 on Saturday 25 August 2007. Respondents who participated in the questionnaire survey had an average age of 39 with a maximum age of 85 and a minimum age of 7. 73 of the total number of respondents were women, and 81 were men, one of 'unknown' gender. On Wednesday 22 August, 68 respondents filled in the handed-out questionnaires and GPS tracking was carried out on 58 respondents. On Saturday 25 August 88 respondents filled in the handed-out questionnaire, and GPS tracking was carried out on 74 respondents.

SKANSEPARKEN AND THE MAPS

The map of surrounding urban areas

Starting from the GPS registrations of respondents' activity patterns in each park a number of GIS-based analyses were made while GIS was also used for drawing up analyses of where people came from in the surrounding urban areas.

The GIS map 'Respondents' latest location position'
The number of respondents from Skanseparken was 156. The map was based on dot information with regard to the respondents' latest location before entering the park. These dots are purposely not indicated on the maps with a view to maintaining the anonymity of the respondents. The buffers indicate the latest positions of the respondents. Each of the four buffers shows 25% of the respondents' latest positions, and in this way the map indicates the surrounding area respondents come from.

The GIS map Density of respondents' latest location
The map indicating the 'density' of the respondents' latest location is based on a calculation of kernel density of one cell dimension of 1x1 m and a search radius of 400 m.

Each of the above-mentioned maps was based on dot information with regard to the respondents' latest location before entering the park. The dots are purposely not indicated on the maps with a view to maintaining the anonymity of the respondents. The original maps were drawn up in A3 using the following scale: large map 1:5,000. Small map 1:100,000. No guarantees are given for these scales after modification of the maps.

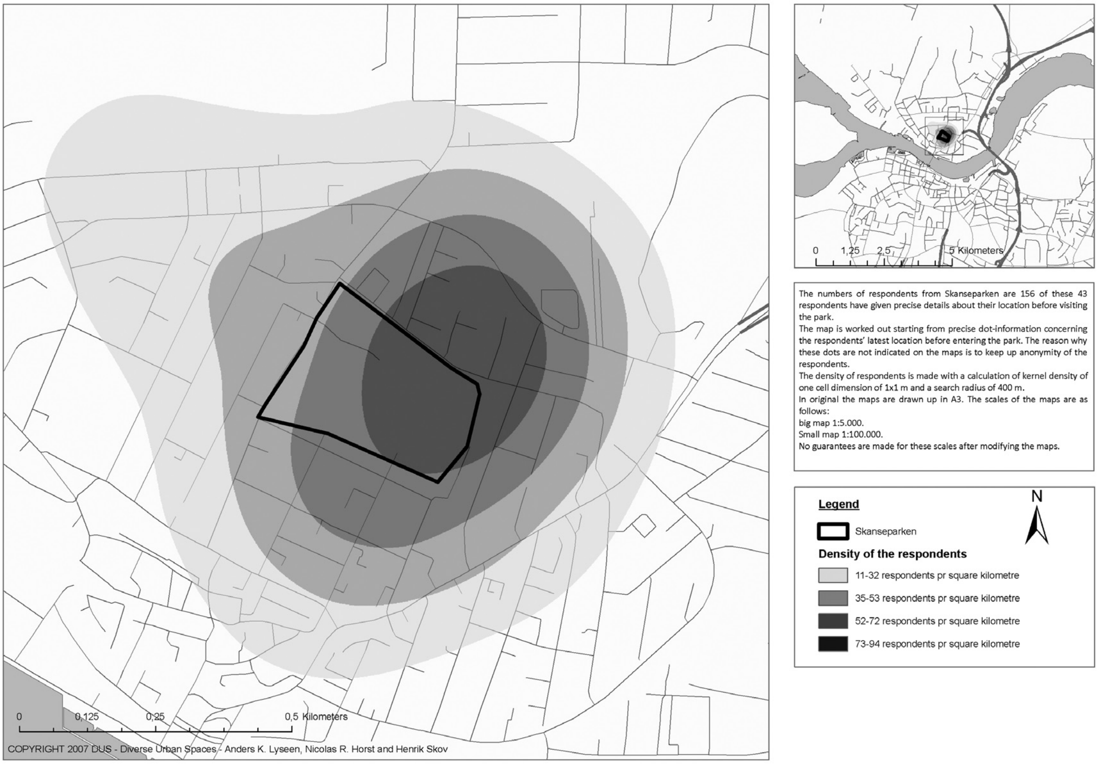


Illustration 6.3 – The GIS map; Respondents' last located position.

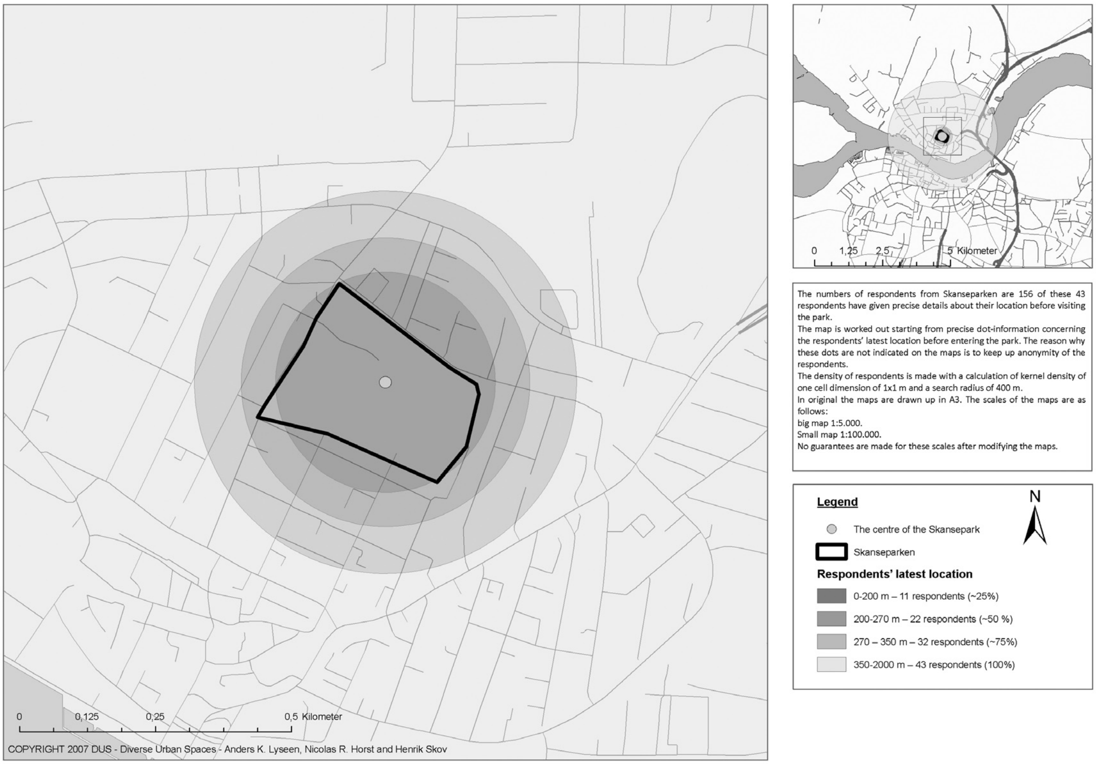


Illustration 6.4 – The GIS map; density of respondents last location.

The park activity map

Parallel to the GIS-based analyses the visualising potentialities of Google Earth have been utilised including an indication of the respondents' accumulated time usage in the parks spread out over 5 x 5 metre grid cells. Google Earth was chosen as it was possible to utilise via free license, it contains information and 3D building layers, and due to its simple KML file structure. In addition it can be used to make results visible to respondents easily, simply, online and in real-time.

The Google Earth map – respondents' accumulated time usage

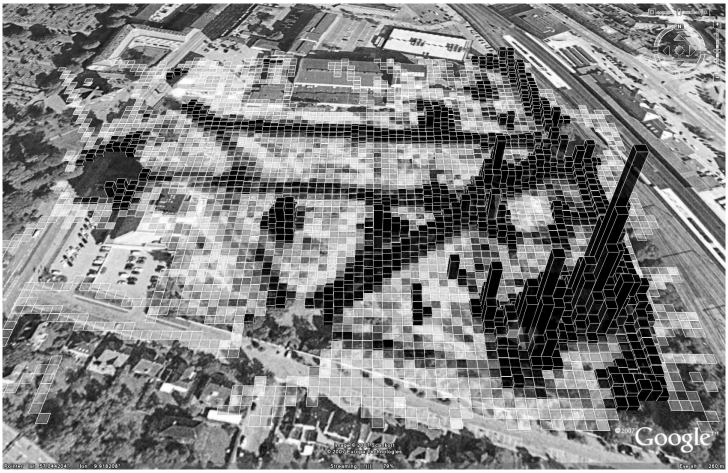
Time usage in the chosen parts of the park spread out over 5 x 5 grid cells. The height and the colour indicate the difference in use of time. The higher the column and the darker the red the more time was spent. A cell with no activity has neither height nor colour. Furthermore the cells within a 25-metre radius from the positions of the survey representatives are excluded with a view to excluding the registration of GPS units not carried by respondents when in the park. The cell with the highest accumulated time usage has a column with a height of 100 metres while all other cells have columns equal in height to the accumulated time usage in the individual cell in proportion to the accumulated time usage in the cell with the highest accumulated usage. This means that a cell with an accumulated time usage equal to 10% of the highest accumulated time usage will have a height of 10 metres. The colour scale is divided into ten steps so that the 10% of the cells with the lowest accumulated time usage are the lightest green and the 10% of the cells with the highest accumulated time usage are the darkest red.

CONCLUSIONS

In the light of the completed research projects, it can be concluded that the results from GPS-based surveys can be absolutely and successfully used to analyze activity patterns and communicate knowledge with regard to the use of specific urban areas to researchers/scientists, professional users and citizens. Depending on which survey set-up is chosen it is however important to consider the ethical set-up and to deliberate how many respondents will take part in the surveys against this background. This will also be the case even if the GPS-based survey only takes place in a park, and even if the respondents are informed that the survey set-up will provide complete and full anonymity.

In relation to the hardware of the methodological set-up it is crucial to attain a satisfactory battery lifetime. In this regard, DUS has mainly found that it is beneficial to use relative simple GPS technology. The spin-off is that the equipment is more easily handled by the respondents. In relation to this challenge is it beneficial to the data quality to let the respondents themselves

Illustration 6.5
3D projections of respondent's accumulated time usage on the Google Earth map.



Kildeparken

Mølleparken

Skansenparken

schedule when to undertake mandatory activities within the project such as answering questionnaires or recharging the units.

Another problem is the representativeness of the results versus the collection cost. Conducting GPS surveys based on handing out GPS units is expensive and can only be carried out a few times and over limited time periods. This means that the results are not statistically representative of overall use as in this case overall use in the four parks. It is hereby important to consider the constitution and representativeness of the respondent group. Some population groups such as children and young people are easily contacted through institutions such as schools and kindergartens whereas recruiting adults as respondents may be less cost effective.

Lastly it is important to consider the trustworthiness of the patterns of activity and to ask whether respondents' activity patterns are influenced by the fact that they know their patterns of activity will be mapped even if registration is completely anonymous, as was the case in the reviewed GPS Park. In addition, a GPS-based survey set-up has a number of minor practical problems concerning the handing out and collecting of GPS hardware units, even if the hardware units do not represent any value to the respondents or are of no use to them afterwards.

In future research within the DUS, the main hypothesis will be that the increasing use of ICT and especially web-based communication is changing socialising, the search for information, shopping and thereby the overall activity patterns of people living in urban areas, and consequently also the use and role of urban space. There is thus a need to rethink the planning of urban space – in contrast to the functionalistic fulfilment of needs and the corresponding functional hierarchies that still dominate within the planning field. GPS-based tracking and surveys based on mobile technologies could be a tool to explore this new reality and thus inform and guide urban planning.

The research with GPS tracking and mobile technologies at Aalborg University was mainly conducted with the following areas of application in mind: firstly the effects of increasing 'virtuality' on the use and role of urban space, and secondly the effects urban areas create on spatial behaviour, transportation, environment and safety, as well as on use patterns, use contexts, and the promotion of use, especially in a health context. Current research efforts mainly point to the use of tracking and mobile technologies in connection with analysis and elaboration, presentation and dissemination in dialogue with the public. The use of GPS tracking and mobile questionnaires as survey technology will be particularly valuable to research into the use and significance of urban space due to the added value of geographical precision and the improved ability to 'record' itineraries through space. The new knowledge that is likely to be derived from this added value will naturally influence the planning process and will most likely strengthen the support provided in connection with decision-making. If it is possible to reduce costs and ethical concerns, mapping and revealing the behaviour of urban populations as an integral part of the planning process will become the norm in the future.

The general experience within the Danish context and the GPS-based research projects has been that visually appealing, easily interpretable, and representative maps of e.g. commuters' behaviour seem to promote the interest of the news media and a wider public interest more strongly than is usual in the planning process. Furthermore, the response of the news media etc. gives the impression that information on what 'we' do, and how and why 'we' do it is popular reading. It is thus suggested that the newness of tracking and mobile technologies as survey devices combined with appealing forms of presentation are likely to succeed in fostering renewed interest in urban space and how it is used. This interest could be used to promote participation and general interest in urban planning. In a wider perspective, the tracking of citizens (GPS-based or GSM-based tracking of volunteers) could be built into future planning processes as an interesting and discussion-raising feature. The tracking and representation of spatial use patterns might also be combined with an interactive dialogue (voting by SMS, Web or Bluetooth, general or place specific) as well as the dissemination of information (SMS, Web, Bluetooth, phone numbers, place specific or general).

ACKNOWLEDGEMENTS

The authors wish to thank Nicolas Rendtlew Horst, Anders Knørr Lyseen and Henrik Skov from Aalborg University for their invaluable contributions in leading and conducting the GPS Park survey.

REFERENCES

- Hovgesen, H.H., Nielsen, T.A.S., Lassen, C. and Godtved, S. (2005) The potential for the exploration of activity patterns in the urban landscape with GPS-positioning and electronic activity diaries. In: *International Conference for integrating Urban Knowledge & Practice: Conference Proceedings*, Life in the Urban Landscape, Gothenburg, Sweden, May 30 – June 4, 2005
- Jensen, F.S. and Guldager, S. (2005) *Den rekreative brug af tre parker i Københavns Kommune – Enghaveparken, Fælledparken og Amager Fælled, 2003-2004*, Københavns Kommune, Copenhagen, available at http://www.vejpark2.kk.dk/publikationer/pdf/408_KBH_rapport_netversion.pdf, accessed 24 July 2008
- Jensen, F.S. (2003) Friluftsliv i 592 skove og andre naturområder, *Skovbrugsserien nr. 32*, Skov & Landskab, Hørsholm, available at http://www.sl.kvl.dk/Videnblade/%7BDDA1C2BF-BAE9-4A9A-8C76-622A53D64F08%7D.pdf
- Kjærsgaard, R., Hovgesen, H.H., Nielsen, T.A.S. and Lassen, C. (2006) Unges mobilitets- og aktivitetsmønstre: undersøgelse baseret på GPS registrering og web-dagbog. Paper presented at *Trafikdage på Aalborg Universitet, Aalborg, Danmark. 28. - 29. Aug. 2006.*
- Ostermann, F. and Timpf, S. (2007) Modelling Space Appropriation in Public Parks, Proceedings *of the 10th AGILE International Conference on Geographic Information Science*, Aalborg University, Denmark.